Manufacturing Related Robotics Technology Needs

In collaboration with the Robotic Industries Association (RIA) we organized a workshop at NIST on the subject of the "Next Generation Robot," (NGR) on August 23. Although the term NGR is very general it was assumed by the workshop participants to refer to industrial manufacturing robots. This was an organizational meeting to initiate a standards development effort to define the safety and performance requirements for the Next Generation Robot (NGR) and to identify research needs. The NGR is envisioned as a circa 2010 machine incorporating inherent safety design and benign operating features which enable and promote lean manufacturing. The meeting offered multiple stakeholders the opportunities to identify and target promising new technologies; establish requirements for interdisciplinary research efforts; and relationship building for the formal standardization effort. This meeting was an open brainstorming session with out-of-the-box thinking encouraged.

Here is the list of the high priority needs, which were identified by the workshop participants (the listing sequence is arbitrary), with some explanatory notes added:

1. **Research that will enable to prove and certify the safety of NGR**
   The best safety equipment will not be good unless the regulatory agencies are convinced that it performs adequately. There is need for research that will enable to move to regulatory change. This could include computer simulations, tests with instrumented dummies, etc., which can be used to validate safety claims and perhaps even rate robots according to their accident prevention capability.
2. **Classify safe robots (validate safety claims)**
   The level of operating safety of a robot cannot be currently recognized from their external appearance and that can expose people to great danger. There is a need to classify robots according to their ability for safe operation and to clearly communicate that information to anyone approaching a robot. The safety classification claim must be validated.
3. **NGR safety credibility for regulators, managers and labor unions**
   The finest standards and safety validations will not be worth very much if the regulators, managers and labor unions do not accept and promote them. A parallel path should be followed where these important players should be engaged and involved in the development of the NGR concept and technology.
4. **Easy lock out**
   Ideally we would like to make lock out as easy as pulling a gate plug, which will increase the level of safety significantly. This work will involve the participation of robot integrators.
5. **Alternatives to initiating an immediate stop (E-Stop) (varying speed, direction, proximity)**
   When the robot emergency stop (E-Stop) is activated it generates significant amounts of stress on the robot and the tools, which are suspended or in contact with the robot arm. A more intelligent robot, which is aware of its environment and the human presence might be able to interact in a more gentle manner, which maintains safety and induces the minimum amount of damage possible.

6. Intelligent robot response to safety emergencies (slow down, change path, notify)

Present robot controllers stop robot motion abruptly during an emergency. Future robots could detect approaching individuals and slow down or move to another direction in an emergency.

7. **Flexible servo drives**

One possible option for the design of safe NGRs is to build them with inherently weak servo drives, which generate enough torque to perform the desired work, but not enough to injure humans. This might be accomplished with a flexible servo drive, which adjusts the maximum torque it can generate according to the needs of the assigned job. Some die-casting robots have a servo float mode, which can control the maximum possible torque that they can apply. How do you measure this torque and classify it according to safety?

8. Position verification

The position and orientation of most robot arms is determined with sensors mounted on the back of the joint drive motors. These sensors can become loose and malfunction and then the arm will move into an unexpected position and orientation. Perhaps an independent sensor or calibration test can prevent an unwanted and unexpected robot arm motion and measure the position and orientation of a 3D moving robot arm even when it is obstructed from direct line of sight view in an industrial environment.

9. Collision detection

Currently used collision detection devices are designed to prevent collision with hardware (objects). Perhaps they should be redesigned to include human collision detection capability.

10. NGR cost should be a consideration

The present cost of safeguarding equipment is approaching that of the robot itself. It is hoped that a significant portion of that cost can be used for building an NGR, which requires less floor space and safeguards. The long-term benefit of such a change should offset any increase in the cost of the robot itself. A significant increase in the robot cost could be counterproductive.

11. Robot-human pain interface (current knowledge from IEEE and Japanese data)

The Japanese have used human subjects in order to collect impact pain data. Similar experiments would be difficult to conduct in the USA.

12. Personal protective equipment (PPE) enabler

It is desirable to have garments or sensors, which alert the robot controller of the identity, presence, location and health condition of a human who has entered its restricted space. Can we though rely on humans to always choose to wear PPE? This is similar to the automobile safety belts regulations problem.

This could be an enabler for NGRs.